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Review Article

CORNFLAKES, WELL-BEING AND COGNITION

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ABSTRACT: ***The aim of the present study was to investigate possible short and longer term benefits of having cornflakes for breakfast. One hundred volunteers were assigned to either the cornflakes condition or "no breakfast" condition for 14 days. At the start and end of the study volunteers came into the laboratory and rated their mood and carried out performance tests. The volunteers then had cornflakes or nothing before completing the tests again. Volunteers continued to consume the cornflakes or nothing throughout the study and rated their health and well-being by completing questionnaires every 7 days. The results showed that the acute effects of consumption of cornflakes were a more positive mood and better recall of a list of words. The cornflakes group were 12.3% more alert than the no breakfast group. The weekly questionnaires also revealed longer term benefits of consuming cornflakes. Those consuming cornflakes reported they felt more rested after sleep, had less constipation, less emotional distress, fewer cognitive difficulties (problems of memory and attention), fewer symptoms and a more positive mood. These effects were apparent for both weeks.***

KEY WORDS: Breakfast, Cognition, Cornflakes, Memory, Mood, Well-Being

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INTRODUCTION

There has been extensive research on the acute behavioral effects of consuming breakfast and the associations between regular breakfast consumption and well-being. Research has not often examined both of these themes and the first aim of the present investigation was to consider both in a single study. In many studies, especially those looking at longer term effects, the nature of breakfast has varied considerably. Breakfast was controlled in the present study by using a widely consumed ready-to-eat high carbohydrate cereal, namely cornflakes. The objective of the research was to identify sensitive measures that can then be used in research aimed at assessing the effect of breakfast type and characteristics of the consumer. Another aim was to review the literature on the Behavioral effects of breakfast to provide a framework into which the present empirical study could be integrated.

Acute effects of breakfast on cognitive function of adults

There has been considerable research on the acute effects of meals on human performance and mood (see Smith and Kendrick, 1992; and Mahoney *et al.,* 2005). Smith (2011) reviewed research designed to investigate whether breakfast influences mood and performance, and to determine whether selective effects are observed depending on the task performed, the type of meal eaten, and characteristics of the person eating the meal. Early studies of the acute effects of breakfast have been criticised for having small sample sizes, for producing inconsistent findings and for largely using subjective assessments (Dickie and Bender, 1982). The range of performance measures used in early research was also small, often being limited to reaction time tasks. However, impaired performance associated with omitting breakfast was observed in some of the early research. For example, King et al (1945) assessed visual and motor functioning 2 h and 3 h after the consumption or omission of breakfast and these functions were impaired when breakfast was not eaten. Other research (Richards, 1972; Lloyd *et al.*, 1996) has shown that performance was most impaired when participants changed from their normal meal. This led to the view that 'the occasional omission of breakfast is worse than the constant omission'.

Benton and Sargent (1992) found that consumption of a protein drink for breakfast increased the speed with which memory tasks were completed. Other research (e.g. Benton and Parker, 1998) has confirmed that breakfast improves aspects of memory. Research findings have also suggested that the size and composition of breakfast influence the post-meal response. Nabb and Benton (2006) compared breakfasts that contained either high or low levels of carbohydrate, fat or protein. Better memory was associated with consumption of meals that more slowly released glucose into the blood. The beneficial effects of a low glycaemic index breakfast have been confirmed in animal studies (Benton *et al.*, 2003) and in studies of children (Wesnes *et al.*, 2003; Ingwersen *et al.*, 2007).

There is some research (Smith *et al.,* 1992; Smith *et al.*, 1994) which has examined the effects of breakfast on mood and a range of different aspects of performance. The type of breakfast was manipulated and the studies also investigated whether personality, eating habits, gender and previous night's sleep modified any effect of breakfast on behavior. The first experiment examined the effects of two types of breakfast on sustained attention tasks (i.e. tasks which show an effect of lunch), mood and cardiovascular functioning. Breakfast had no effects on performance of sustained attention tasks and no interactions between breakfast conditions and personality or gender were found. Smith et al (1994) examined effects of breakfast on performance of memory tasks. Consumption of breakfast improved recall and recognition of a list of words but had no beneficial effects on working memory or semantic memory tasks. Again, effects of breakfast were not modified by caffeine or by personality and gender. Breakfast had no effect on episodic memory in the late morning or after lunch, which suggests that the effects of breakfast on memory are restricted to a few hours after the meal. Smith et al (1998) showed that consumption of breakfast improves spatial memory. However, the most robust effects of breakfast on memory in these studies were found in free recall tasks and these effects have also been observed after consumption of cereal bars for breakfast (Smith and Wilds, 2009; Smith and Stamatakis, 2010).

Most of the studies of the acute effects of breakfast have used samples of young adults. There have been a few studies that have examined effects of breakfast in elderly adults. Kaplan et al (2001) found that a protein breakfast was associated with reduced forgetting in a paragraph recall task whereas carbohydrate intake was associated with improved performance of a short-term memory task. Smith (1998) found that elderly adults who ate breakfast cereal every day performed better on an intelligence test than those who consumed breakfast less often. This could reflect an effect of intelligence on breakfast consumption rather than a causal effect of breakfast.

Effects of breakfast on the cognition and academic attainment of children and adolescents

There have been a number of reviews of the effects of breakfast on the cognitive performance of adolescents and children (Rampersaud *et al.*, 2005; Mahoney *et al.*, 2005; Hoyland *et al.,* 2009). There have been over forty studies published on this topic in the last 60 years (see Hoyland *et al.,* 2009 for details of the literature). The results confirm the adult literature showing that breakfast has a beneficial effect on cognition, with the strongest support for improved memory. This effect is most readily apparent when nutritional status is compromised. Less is known about the effects of different types and sizes of breakfast so the role of breakfast size and composition requires further consideration. Wyon et al. (1997) reported that children did better when they consumed a high energy breakfast compared to consumption of a low energy breakfast. Michaud et al (1991) confirmed these results using a short-term memory task. Other research (Mahoney *et al.*, 2005) suggests that an oatmeal breakfast leads to better performance compared to a ready-to-eat cereal. Most studies have investigated young children rather than adolescents. A study of high school students (Widenhorn-Muller *et al.*, 2008) showed that breakfast improved visuo-spatial memory in males. Studies of school breakfast programmes suggest that such interventions can have positive effects which may reflect effects of these programmes on school attendance, a superior nutritional profile or better weight management.

Effects of breakfast on mood

Research has shown that shortly after consumption of breakfast people report a more positive mood. Maridakis et al (2009) reported that these effects could be demonstrated using a range of measuring instruments. Similarly, improved mood has been found with different types of breakfast (e.g. Smith *et al.*, 1992) and when volunteers were free to select from a range of breakfast cereals (Smith *et al.*, 1999) or cereal bars (Smith and Wilds, 2008). These results have been confirmed in studies of children (Smith, 2010) and adolescents (Widenhorn-Muller *et al.*, 2008). Other research has suggested that different macronutrients have selective effects on mood (e.g. simple versus complex carbohydrates, Pasman *et al.*, 2003) although it is often unclear whether such effects reflect factors such as acceptability of the breakfast. Other results show that mood is more negative after a low energy rather than high energy breakfast (Lluch *et al.*, 2000). Effects of habitual consumption may also modify the acute effects of breakfast, with changes from habitual breakfast being associated with a more negative mood (Lloyd *et al.*, 1996). The effects of habitual breakfast consumption patterns on longer-term well-being will now be considered.

Breakfast and well-being

It is now accepted that there is more to health than the absence of disease which has led to greater interest in quality of life and well-being. Smith (2003) has suggested that well-being is related to the ability to function well (both physically and mentally) and to have a positive mood state. The term "functional food" refers not only to the beneficial effects related to chronic disease but to the potential for improved well-being. Regular consumption of breakfast has been shown to be associated with various aspects of the multi-dimensional concept of well-being and some examples are given in the following section.

Wetzler and Ursano (1988) in a cross-sectional analysis of over 6,000 individuals found that breakfast consumption was associated with better psychological well-being. Similarly, Tanaka et al (2008) in a study of medical students found that skipping breakfast was associated with an increased prevalence of fatigue. Huang et al (2010) examined associations between breakfast skipping and health-related quality of life in a national representative sample (N=15,340) from the 2005 Taiwan National Health Interview Survey. The results showed that breakfast skippers had significantly lower scores on 5 out of the 8 domain scores on a quality-of-life questionnaire (the SF-36: lower general health; reduced vitality; poorer social functioning; poorer emotional roles; and reduced mental health).

Smith (1998) examined the relationship between breakfast consumption and subjective reports of health and health related behaviors in a general population sample. Those who consumed a cereal breakfast each day were less depressed, less emotionally distressed and had lower levels of perceived stress than those who did not eat breakfast every day. Those who consumed breakfast were less likely to be smokers, drank less alcohol and had a healthier diet. However, the relationship between breakfast cereal consumption and mental health did not reflect differences in the other health-related behaviors. A subsequent study (Smith, 1999) attempted to replicate and extend the above result. Individuals who consumed breakfast cereal every day reported better mental and physical health than those who consumed it less frequently. This association was still present when demographic factors, indicators of lifestyle such as smoking, or other aspects of diet were co-varied. Smith (2003) considered young adults living at home. The results showed that skipping breakfast was associated with reports of poorer health and that regular breakfast cereal consumption was associated with better health. Again, the effects of breakfast could not be accounted for by other health-related behaviors or other aspects of diet.

Smith (2010) conducted an intervention study with two hundred and thirteen primary school children, (108 female, 105 male; mean age: 8.11 years, s.d. 2.04 years). Baseline measures of breakfast consumption and different aspects of reported well-being, such as mental health; cognitive functioning; alertness; physical health; and digestive problems, were recorded. Following this, children were allowed to try three cereals and selected the one that they found most acceptable. The groups consumed these cereals on a daily basis for two weeks. Measures of well-being were recorded on days 7 and 14. The breakfast cereal groups were compared with children who consumed no breakfast. The baseline results showed that those who regularly consumed breakfast cereal were perceived as having better well-being including fewer mental health problems, a more positive mood, higher alertness and fewer bowel problems than those who did not usually consume breakfast. These results were confirmed in the intervention study with those consuming breakfast cereals reporting less depression, emotional distress and fatigue, greater alertness, fewer cognitive problems, and fewer minor symptoms and bowel problems. These effects were apparent after both the first and second week and were also observed for all cereals.

There is evidence that breakfast consumption per se improves well-being and that effects appear to be most pronounced with breakfast cereal in combination with dairy products (O'Sullivan *et al.*, 2009). One type of breakfast cereal that has a large effect is high fibre cereal. Increasing dietary fibre from wheat bran cereals decreases fatigue and increases energy (Smith *et al.*, 2001). Smith (2012) conducted secondary analyses of data to examine associations between habitual high fibre intake and well-being. The results showed that high fibre intake was associated with increased well-being. Subsequent analyses examined whether the effects of fibre could be accounted for by ingestion of specific sources of fibre. The results showed that it was the high fibre breakfast cereal that was largely responsible for the increased well-being. Digestive problems can lead to reduced well-being and a second set of analyses examined whether the benefits of fibre were due to a reduction in digestive problems. The results showed that digestive problems reduced well-being but these effects were independent of the effects of fibre.

Underlying mechanisms

Results show that consumption of breakfast improves mood and cognition compared to eating no breakfast. It has been suggested that breakfast removes the negative effects of fasting and the mechanism has often been conceptualised in terms of providing a supply of energy to the brain. A large number of studies have examined the effects of glucose on behavior and a number of studies have demonstrated beneficial effects of glucose on verbal memory (Hoyland *et al.*, 2008). Other research has investigated the effects of meals differing in glycaemic index (GI), glycaemic load (GL), the ratio of slow/rapid availability of glucose, the proportion of simple to complex carbohydrate, or the amount of rapidly versus slowly digested carbohydrate. Gilsenan et al (2009) have reviewed studies comparing the impact of different GLs. Their conclusion was that there is insufficient evidence to support a consistent effect of GL on cognitive performance. Another study (Micha *et al.*, 2010) examined the effects of glycaemic potency (combinations of GI and GL) on cognitive performance of children aged 11-14 years. A low-GI/high GL breakfast was associated with faster information processing whereas a high GI breakfast was associated with better immediate word recall.

The research to date does not inform on the precise mechanisms through which glucose influences cognition. The possible mechanisms are many and varied. For example, glucose is taken up by astrocytes, converted into lactate which is then released into extra-cellular space to be taken up as an energy substrate by neurons. Many of the brain's neurotransmitters are derived from glucose metabolism which suggests that glucose may influence cognitive function by enhancing neurotransmitter synthesis during periods of neuronal activity. Alternatively, there could be a peripheral effect of glucose on memory due to a neural signal being triggered when glucose is transported into cells. GL may also influence gastro-intestinal hormonal response which in turn may have effects on cognition. Factors such as food acceptability may also be related to levels of circulating glucose and these variables must be controlled when assessing the impact of different meals. There are clearly other mechanisms through which consumption of breakfast may influence behavior. These may reflect the macronutrient composition (e.g. effects of high fibre cereals), the micronutrient composition (e.g. fortification of cereals) or a more general influence on dietary intake and health.

Effects on real-life cognitive function and safety

The major practical implications of breakfast consumption are in the areas of nutritional intake, weight management and health. Studies of children suggest that breakfast consumption may improve cognition and school attendance which leads to better academic achievement. Reviews of breakfast consumption and children's academic achievement (e.g. Ells *et al.*, 2008) have concluded that there are short-term benefits. However, there is little consistency in the methodology across studies and the research often has methodological problems. Most breakfast interventions have been of short duration and the results fail to quantify sustainability and longer-term benefits.

Until recently little was known about the real-life behavioral benefits of consuming breakfast for adults. For example, a literature search conducted in 2010 revealed no information on breakfast and accidents and errors at work (or outside of work), road traffic accidents or driving performance, or on productivity at work. Chaplin and Smith (2011) examined effects of breakfast consumption on the health and safety of a sample of 870 nurses. The results showed that accidents, injuries and cognitive failures at work were greater in those who rarely ate breakfast. In addition, stress at work was greater in the breakfast skippers. Further research is now required to extend these findings to consider real-life activities outside of the workplace It is also essential to carry out interventions rather than just cross-sectional analyses. A pre-requisite of this research is that one identifies measures which are sensitive indicators of effects of breakfast. The study reported here examined this issue by investigating acute effects on mood and performance along with longer-term changes in well-being.

MATERIALS AND METHODS

The study was carried out with the approval of the ethics committee, School of Psychology, Cardiff University, and the informed consent of the volunteers.

Sample:

One hundred and thirty volunteers were recruited into the study. 103 of this sample began the study and 100 participants completed it. The twenty-eight participants who did not take part were unable to attend on the dates/times specified.

Exclusion criteria:

Exclusion form the study was determined as; (a) Participants with an existing disease or long term medication; (b) Those who were heavy smokers (i.e. >10 cigarettes a day) or alcohol consumption above 20 units a week (females) and > 30 units a week (males), (c) relevant food allergies.

Inclusion criteria:

Participants had either; (a) to be willing to consume cornflakes every day for 14 days or (b) to be willing to abstain from eating breakfast for 14 days.

Design:

A separate groups design was used with half the volunteers consuming cornflakes for 14 days and the other group no breakfast.

Randomisation:

All 130 recruited participants were randomised by SPSS taking gender into consideration.

Measures:

Volunteers completed a battery of questionnaires at baseline, 7 days later and on day 14. These assessed fatigue and energy levels, subjective ratings of mood and physical and mental health measures (see Table 1). These are validated measures which have been shown to be sensitive to nutritional manipulations (Smith, 2010; Smith et al., 2001).

TABLE 1. Questionnaires completed on days 1, 7 and 14

Profile of fatigue related states – *measures fatigue, emotional distress, cognitive difficulties and somatic symptoms* (Ray *et al.*, 1992)
Hospital Anxiety and Depression Scale – *measures anxiety and depression* (Zigmond and Snaith, 1983)
Symptom checklist – *26 items* (Smith *et al.*, 2001)
Digestive Symptoms (Smith *et al.*, 2001)
Sleep Questionnaire – *measures duration and quality of sleep, 4 items* (Smith *et al.*, 2001)
Mood states this week – *measures positive and negative mood* (Zevon and Tellegen, 1982)

TABLE 2. Mood and performance measures.

Mood
This was measured using 18 bi-polar visual analogue scales (e.g. Drowsy-Alert, Tense-Calm; see Smith et al., 1995) presented on the screen of an IBM compatible computer.
Performance tasks A battery of tests was used that measure a range of functions. All of these tests were presented on an IBM compatible PC.
Memory tasks: *Free Recall Task*
A list of 20 words was presented on the PC screen at a rate of one every 2 seconds. At the end of the list, the subject was given 2 minutes to write down (in any order) as many of the words as possible.
Delayed Recognition Memory Task
At the end of the test session, subjects were shown a list of 40 words, which consisted of the 20 words shown at the start of the session plus 20 distracter words. The subjects had to decide, as quickly as possible, whether each word was shown in the original list or not.
Logical Reasoning Task
In this task, the subjects were shown statements about the order of the letters A and B followed by the letters AB or BA (e.g. A follows B: BA). The subjects had to read the statement and decide whether the sentence was a true description of the order of the letters. If it was, the subject pressed the T key on the keyboard; if not, they pressed the F key. The sentences ranged in syntactic complexity from simple active to passive negative (e.g. A is not followed by B). Subjects carried out the task for 3 minutes.
Semantic Processing Task
This test measured speed of retrieval of information from general knowledge. Subjects were shown a sentence and had to decide whether it was true (e.g. canaries have wings) or false (e.g. dogs have wings). The number completed in 3 minutes was recorded.
Psychomotor tasks:
Variable Fore-Period Simple Reaction Time Task
This task was performed for 3 minutes. An empty box (warning signal) was displayed on the screen and this was followed by a filled in square (the target) being presented in the middle of the box. The time interval between the warning and target presentations was variable (1 to 8 seconds). The subject had to press a key as soon as the target square was detected.
Selective attention tasks:
Focused Attention Task
This choice reaction time task, developed by Broadbent et al (1986, 1988), measured various aspects of performance. In this task target letters appeared as upper-case A's and B's in the centre of the screen. Participants were required to respond as quickly and as accurately as possible to the target letter presented in the centre of the screen, ignoring any distracters presented in the periphery. The correct response to the letter A was to press the key marked A with the forefinger of the left hand while the correct response to B, was to press a key marked B, with the forefinger of the right hand. Prior to each target presentation three warning crosses were presented on the screen; the outside crosses were separated from the middle one by either 1.02 or 2.60 degrees. The crosses were on the screen for 500 ms and were then replaced by the target letter. The central letter was either accompanied by: (1) nothing, (2) asterisks, (3) letters which were the same as the target or (4) letters which differ from the target. The two distracters presented were always identical and the targets and accompanying letters were always A or B. Participants were given ten practice trials followed by three blocks of 64 trials. In each block, there were equal numbers of near / far conditions, A or B responses and equal numbers of the four distracter conditions. The nature of the previous trial was controlled. This test lasted approximately 3 minutes. In this task, several aspects of choice responses to a target can be measured. The global measures of choice reaction time were mean reaction time and accuracy of response (percent correct) when the target is presented alone or when distracters were present. Long response times (> 800msec) were also recorded. In addition, a measure of selective attention was recorded (the Erikson effect). This provides a measure of focusing of attention, describing the effect of spatial interference caused by disagreeing stimuli placed near to or far from the target upon reaction time and accuracy of response to the target. A more specific aspect of choice response was measured recording choice reaction time and accuracy with which new information was encoded e.g., alternations and repetitions of responses to the target.
Categoric Search Task
This task was also developed by Broadbent et al (1986, 1989) and was similar to the focused attention task previously outlined. Each trial started with the appearance of two crosses either in the central positions occupied by the non-targets in the focused attention task i.e., 2.04 or 5.20 degrees apart or further apart, located towards either left and right extremes of the screen. The target letter then appeared in place of one of these crosses. However, in this task participants did not know where the target would appear. On half the trials, the target letter A or B was presented alone and on the other half it was accompanied by a distracter (in this task a digit (1-7)). Again, the number of near/far stimuli, A versus B responses and digit/blank conditions were controlled. Half of the trials led to compatible responses (i.e., the letter A on the left side of the screen, or letter B on the right) whereas the others were incompatible. The nature of the preceding trial was also controlled. In other respects (practice, number of trials, etc.) the task was identical to the focused attention task. As in the focused attention task several aspects of choice responses to a target were measured. The global measures recorded were choice reaction time and accuracy of response when the target was presented alone in either near/far locations. Long response times (> 800 msecs) were also recorded. A more specific aspect of choice response was measured, recording choice reaction time and accuracy with which new information was encoded. In addition, specific aspects of selective attention were measured. For each of these variables outlined below, mean reaction time and accuracy were calculated. A measure of response organisation was recorded. This refers to the effect of compatibility of the target position and the response key upon reaction time and accuracy. A further measure of place repetition was taken which refers to the effect of target location (i.e., the target appearing in the same or a different place on successive trials). A measure of spatial uncertainty was also taken which describes the extent to which not knowing the location of the target (in near or far locations) hinders both reaction time and accuracy.
Sustained Attention Task:
Repeated-digits Vigilance Task
Three-digit numbers were shown on the screen at the rate of 100 per minute. Each was normally different from the preceding one but occasionally (8 times/minute) the same number was presented on successive trials. Subjects had to detect these repetitions and respond as quickly as possible. The number of hits, reaction times for hits, and false alarms were recorded. The task lasted for 3 minutes.

Measurement of cognitive performance and mood were included in the study at the start and end of each condition. These included measures of mood, memory and attention. Full details of the tests are given in Table 2. These are validated measures which have been shown to be sensitive to changes in state produced by nutritional and other manipulations (see Smith *et al.*, 1995).

The following mood and performance tests were used because they are reliable and sensitive measuring instruments that assess a range of cognitive abilities (selective and sustained attention, episodic, working and semantic memory, psychomotor speed etc.). They are also in a form that is easy to use by a wide cross-section of the population.

Testing Schedule:

Day 1:

There were 2 testing time slots at 7 and 8 am.

- Volunteers completed the pre-breakfast laboratory based tasks and baseline questionnaire between 7 and 8am

TABLE 3. Demographic data for the study participants. Data are represented as a percentage (number) or group means (s.e.m) and split by condition.

	Cornflakes	No Breakfast
Gender:		
Male	51.4 (18)	48.6 (17)
Female	53.8 (35)	46.2 (30)
Age (years)	25.3 (1.0)	27.9 (1.4)
Smokers (%, N)	9.4 (5)	6.4 (3)
Alcohol Consumption:	54.9 (50)	45.1 (41)
Frequency of alcohol consumption:		
Hardly ever (%, N)	10.0 (5)	19.5 (8)
Some weeks	16.0 (8)	17.1 (7)
Most weeks	26.0 (13)	31.7 (13)
Every day	48.0 (24)	31.7 (13)
Mean number of units of alcohol per week	14.0 (1.2)	11.1 (1.2)
Breakfast Habit:		
Never (%, N)	9.4 (5)	10.6 (5)
Sometimes	26.4 (14)	27.7 (13)
Always	64.2 (34)	61.7 (29)
What would you normally eat:		
Nothing (%,N)	11.3 (6)	10.6 (5)
Toast	15.1 (8)	0 (0)
Cereal	34.0 (18)	38.3 (18)
Toast and cereal	11.3 (6)	21.3 (10)
Muesli/porridge	5.7 (3)	4.3 (2)
Fruit	1.9 (1)	0 (0)
Cooked breakfast	0 (0)	2.1 (1)
Other	1.9 (1)	0 (0)
Combination of the above	18.9 (10)	23.4 (11)
What would you normally drink:		
Nothing (%, N)	11.3 (6)	14.9 (7)
Non-caffeinated drink	47.2 (25)	36.2 (17)
Coffee	13.2 (7)	10.6 (5)
Tea	15.1 (8)	25.5 (12)
Coffee and Tea	1.9 (1)	0 (0)
Combination of caffeinated and non-caffeinated drinks	9.4 (5)	2.1 (1)
Other	1.9 (1)	10.6 (5)
How would you describe your normal breakfast?		
Light (%, N)	64.7 (33)	55.8 (24)
Medium	33.3 (17)	44.2 (36)
Heavy	2.0 (1)	0 (0)

TABLE 4. Acute effects of consuming cornflakes (Scores are the adjusted means)

		Cornflakes	No breakfast
Mood (High scores = more positive mood)			
Alertness prior to testing	Day 1	246	219
	Day 14	236	215
Main effect of breakfast : F1, 97 = 11.7 p<0.001			
Alertness after testing	Day 1	216	189
	Day 14	216	189
Main effect of breakfast : F1, 97 = 4.40 p<0.05			
Hedonic tone prior to testing	Day 1	192	173
	Day 14	183	175
Main effect of breakfast : F1, 97 = 10.73 p<0.01			
Hedonic tone after testing	Day 1	181	161
	Day 14	181	161
Main effect of breakfast : F1, 97=2.69 p=0.10			
Calm prior to testing	Day 1	91	86
	Day 14	90	85
Main effect of breakfast : F1, 97 = 4.68 p<0.05			
Calm after testing	Day 1	91	86
	Day 14	91	86
F1, 97 = 1.50 p=0.22			
Free recall (number of words recalled)	Day 1	10.7	10.1
	Day 14	11.1	10.3
Main effect of breakfast : F1, 97 = 3.33 p<0.05, 1 – tail			

- At 8am participants were either given breakfast cereal or received no breakfast
- 9am participants complete the post-breakfast testing session

or

- Volunteers completed the pre-breakfast laboratory based tasks and baseline questionnaire between 8 and 9am
- At 9am participants were either given breakfast cereal or received no breakfast
- 10am participants complete the post-breakfast testing session

Participants were given a questionnaire booklet to complete on day 7 and return it to the Unit.

Day 14:

Participants returned to the laboratory and repeated the computerised tasks pre- and post- breakfast and a day 14 questionnaire booklet.

Statistical Analysis:

The baseline characteristics of the cornflake/no-breakfast groups were compared using Chi-squared and ANOVA analyses. The final database was run through analyses of co-variance. The first factors to be entered into the model were the baseline measures which were used as covariates. These were followed by the cornflakes or placebo condition.

RESULTS

One hundred and three participants began the study. Two withdrew before day 7; one due to illness, the other because the no-breakfast condition was unacceptable to them. When the final database was constructed, one participant's data was excluded due to computer error during the performance tasks. This resulted in 100 participants in the final database.

53 of the final cohort were randomised into the cornflake condition and 47 into the no-breakfast condition.

Participant Demographics:

Table 3 describes the demographic data for the 100 participants

TABLE 5. Weekly questionnaires (Scores are the adjusted means from the analyses of covariance; s.e.s in parentheses)

		Cornflakes	No breakfast
Rested sleep (High scores = more rested after sleep)	Week 1	2.24 (0.11)	2.00 (0.12)
	Week 2	2.21 (0.11)	1.95 (0.12)

Main effect of breakfast: $F_{1,96} = 4.41$ $p<0.05$

Constipated (High scores = greater constipation)	Week 1	0.22 (0.14)	0.74 (0.15)
	Week 2	0.26 (0.14)	0.61 (0.15)

Main effect of breakfast : $F_{1,96} = 8.41$ $p<0.005$

Emotional distress (High scores = more distress)	Week 1	32.9 (2.3)	37.1 (2.45)
	Week 2	30.7 (2.3)	36.6 (2.45)

Main effect of breakfast : $F_{1,93} = 4.45$ $p<0.05$

Fatigue (High scores = greater fatigue)	Week 1	25.7 (2.02)	27.8 (2.2)
	Week 2	24.1 (2.02)	29.2 (2.2)

Main effect of breakfast : $F_{1,94} = 2.89$ $p= 0.09$

Cognitive difficulties (High scores = more problems)	Week 1	25.7 (1.8)	29.7 (1.9)
	Week 2	25.4 (1.8)	30.9 (1.8)

Main effect of breakfast : $F_{1,94} = 6.31$ $p<0.05$

Positive mood (High scores = more positive mood)	Week 1	32.6 (1.25)	28.4 (1.35)
	Week 2	33.7 (1.25)	28.1 (1.35)

Main effect of breakfast : $F_{1,96} = 14.08$ $p<0.0005$

Negative mood High scores = more negative mood)	Week 1	17.3 (1.4)	19.5 (1.5)
	Week 2	16.0 (1.4)	19.0 (1.5)

Main effect of breakfast : $F_{1,96} = 2.92$ $p=0.09$

Somatic symptoms (High scores = more symptoms)	Week 1	24.5 (1.7)	28.4 (1.8)
	Week 2	24.9 (1.7)	28.0 (1.8)

Main effect of breakfast : $F_{1,94} = 4.02$ $p<0.05$

Total symptoms (number)	Week 1	3.6 (0.58)	5.2 (0.62)
	Week 2	3.9 (0.58)	5.6 (0.62)

Main effect of breakfast : $F_{1,96} = 7.4$ $p<0.01$

who completed the study. There were no significant differences between the two groups in terms of demographic and breakfast habit data.

Acute effects of consuming cornflakes:

Analyses of co-variance were conducted on the post-breakfast data for days 1 and 14 using the pre-breakfast scores as covariates. Table 4 shows the results. Consumption of cornflakes was associated with significantly greater alertness, higher hedonic tone and greater calm especially at the start of the test session. The number of words recalled was also greater in the cornflake condition. There were no other significant effects on the performance tasks.

Longer term effects of consuming cornflakes:

Results from the questionnaires showed that those consuming cornflakes reported they felt more rested after sleep, had less constipation, less emotional distress, fewer cognitive difficulties (problems of memory and attention), fewer symptoms and a more positive mood. These effects were apparent for both weeks (see Table 5).

DISCUSSION

The present article consists of a review of the breakfast and behavior literature followed by an empirical study designed to identify measures which were sensitive to the acute and longer-term effects of consuming breakfast. The obvious conclusion to be drawn from the literature reviewed here is that breakfast is good for you. This is true when one considers a number of different areas such as nutritional intake, weight management and health. The same conclusion applies when one considers behavioral outcomes, with breakfast being associated with a more positive mood, improved cognition and, in the longer term, better well-being. These findings were replicated in the present intervention study which has identified sensitive measures for use in future research. These conclusions generally hold for well-nourished children, children with nutritional deficiencies and adults (young, middle-aged and the elderly). Given the robust evidence for beneficial effects of breakfast it is rather surprising that we have made relatively little progress in understanding the underlying mechanisms (both psychological mechanisms and the CNS changes that underpin these). Furthermore, compared to other aspects of eating and drinking (e.g. consuming caffeine) we know relatively little about the practical benefits of breakfast at work, rest and play. Future research must extend our current knowledge by conducting translational research that will provide appropriate information for future policy and practice.

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Conflict of interest

The author declares no conflict of interest.

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